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SIMULATION AND ANALYSIS OF A GEOPOTENTIAL RESEARCH MISSION

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Major Events

1. Research results for the first simulation of GRM (8508) were published in *manuscripta geodaetica*, Vol. 12, pp. 51-63, 1987. A copy of this report was submitted with the previous semi-annual report. This represents the completion of the first-year efforts.
2. A presentation of current research results pertaining to GRM was made at the American Geophysical Union Spring Meeting in Baltimore on May 18, 1987. The presentation consisted of a 15 minute oral presentation. A copy of the abstract and slides presented at the meeting are enclosed.
3. The current research results are being prepared for publication in a refereed journal. The manuscript is in preparation and will be forwarded as soon as possible. Publication of this paper will mark the completion of the second-year efforts.

Present Research Activities

Recent efforts have centered on :

1. the production of the second GRM simulation (S8703),
2. studies of the selection of initial conditions to meet the ground track and relative drift requirements of the mission,
3. studies of the orbit adjustments required to compensate for orbital insertion and mission planning uncertainties,
4. studies of the procedures to meet the orbit determination requirements of the mission, and
5. studies of the drag compensation mechanism and the subsequent implications for GRM.

The results for item 1 are being prepared for publication in a refereed journal. The results for items 2, 3, and 4 are being prepared as part a doctoral dissertation that should be completed this summer. The results for item 5 are being prepared as part of a masters thesis that should be completed this fall.

In preparation for the third-year efforts, plans are underway to implement studies into:

1. possible tracking systems for GRM,
2. the recovery of the geopotential coefficients using classical techniques,
3. the production of a GRM simulation with gravity gradiometer measurements, and
4. including additional, time varying components of the force field in the simulation of GRM.

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RECENT DEVELOPMENTS IN THE SIMULATION OF A GEOPOTENTIAL RESEARCH MISSION

J. B. Lundberg (Center for Space Research, The University of Texas at Austin, Austin, TX 78712)
B. E. Schutz, B. D. Tapley, L. White, and P. Antreasian

Computer simulations have been performed for a Geopotential Research Mission (GRM) to enable the study of the gravitational sensitivity of the range-rate measurements between the two satellites and to provide a set of simulated measurements to assist in the evaluation of techniques developed for the determination of the gravity field. The simulations were conducted with two satellites in near-circular, frozen orbits at 160 km altitudes separated by 300 km. High precision numerical integration of the polar orbits was used with a gravitational field complete to degree and order 360. The set of simulated data for a mission duration of about 32 days was generated on a Cray X-MP computer. The results presented in this report cover the most recent simulation, S8703, and includes a summary of the numerical integration of the simulated trajectories, a summary of the requirements to compute nominal reference trajectories to meet the initial orbit determination requirements for the recovery of the geopotential, an analysis of the nature of the one-way integrated doppler measurements associated with the simulation, and a discussion of the data set to be made available.

1. 1987 Spring Meeting
2. SCHU027799
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RECENT DEVELOPMENTS IN THE SIMULATION OF A GEOPOTENTIAL RESEARCH MISSION

J. B. LUNDBERG, B. E. SCHUTZ, B. D. TAPLEY
L. K. WHITE, and P. ANTREASIAN

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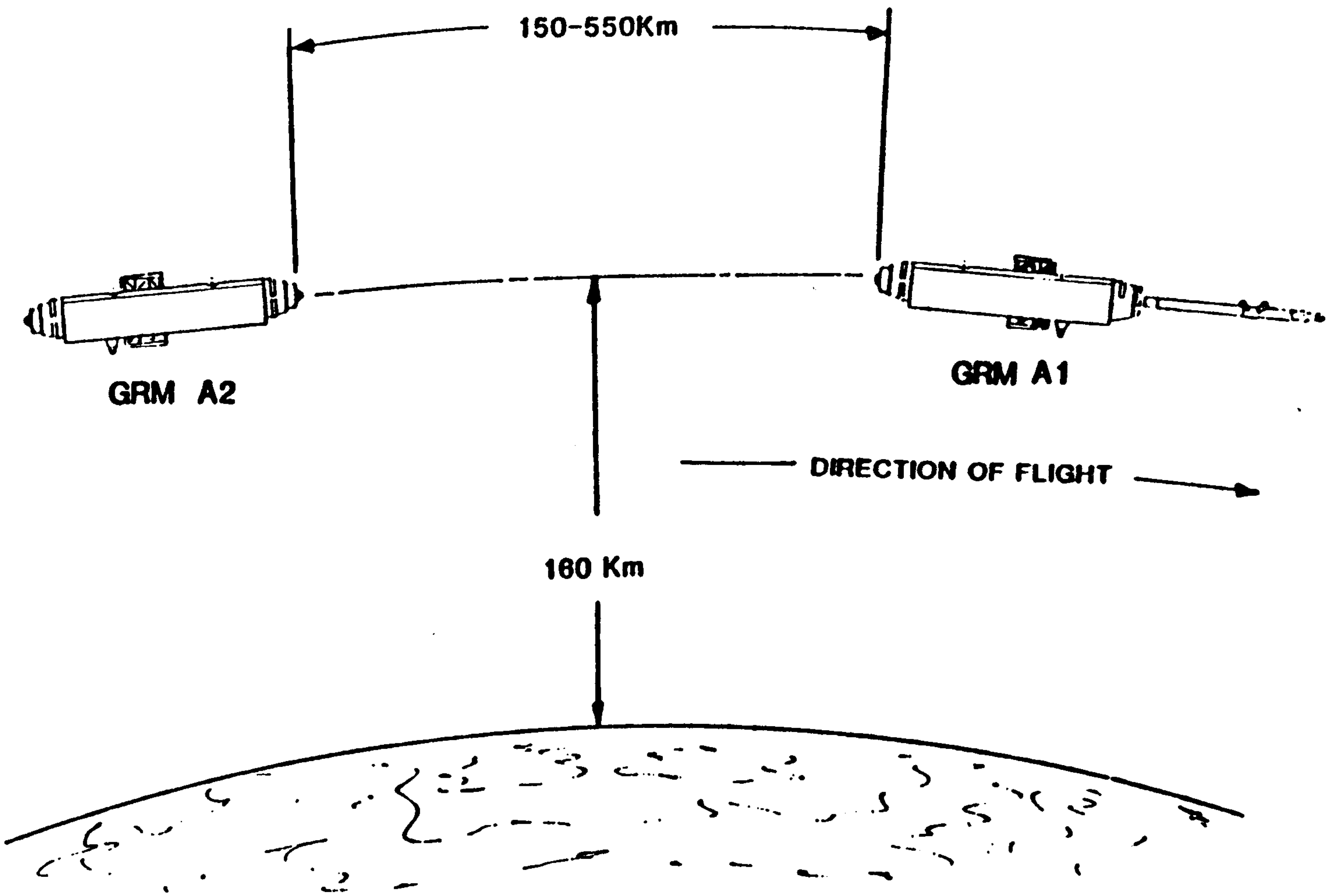
Presented at the
American Geophysical Union
Spring 1987 Meeting
Baltimore, Maryland

May 18, 1987



GRM FLIGHT PROFILE

REVIEW OF SIMULATIONS

Objective: The creation of a simulated GRM data set:

- to study the gravitational sensitivity of range-rate measurements between two satellites

- for the evaluation of techniques developed for gravity recovery from range-rate measurements

OUTLINE OF GRM SIMULATION 8505

- 32 sidereal days
- Geopotential field complete to degree and order 180 plus orders 0 through 10 to degree 300 (Rapp, OSU)

$$GM = 3.986013 \times 10^5 \ km^3/sec^2$$

$$a_e = 6378.155 \ km$$

- Constant Earth angular velocity vector
- Tides and luni-solar effects not included
- Nongravitational effects not included
- Instantaneous range and range-rate measurements at 5-second intervals
- Nominal ephemeris based upon GEM-10B

OUTLINE OF GRM SIMULATION S8703

- 32 sidereal days
- Geopotential field complete to degree and order 360 (Rapp, OSU)

$$GM = 3.9860044 \times 10^5 \text{ km}^3/\text{sec}^2$$

$$a_e = 6378.137 \text{ km}$$

- Constant Earth angular velocity vector
- Tides and luni-solar effects not included
- Nongravitational effects not included
- Integrated, one-way doppler measurements as measured at each satellite at 4-second intervals
- Nominal ephemeris based upon GEM-10B

COMPUTATION OF EPHEMERIDES

Method

- Encke formulation of the equations of motion
- Class 2, fixed-mesh, multistep algorithm of order 10
- CRAY X/MP-24

Comparison

	S8508	S8703
Stepsize (sec)	5	4
Cost per function evaluation (msec)	8.3	23.6
Run time (hr)	5.6	19.2
Ground track closure after 32 days (km)	~2 km	~2 km

FIT OF NOMINAL REFERENCE ORBIT TO S8703

- Mission requirements for nominal orbit:

Radial position errors (3σ):	100 m
Along-track position errors (3σ):	300 m
Cross-track position errors (3σ):	100 m

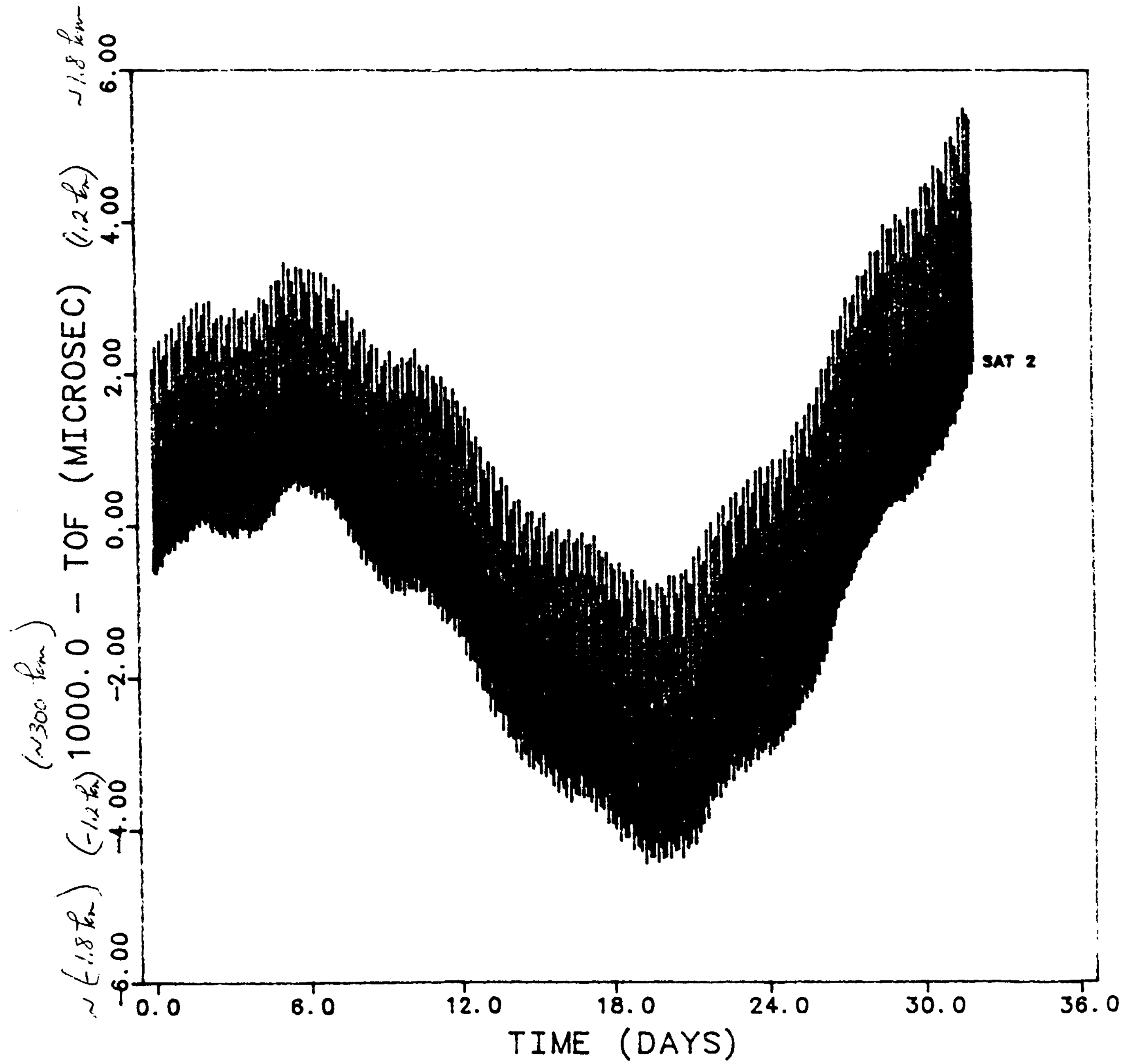
- Fitting GEM-10B ephemeris to S8703 resulted in RMS differences of several kilometers

- To meet mission requirements, gravitational coefficients based upon GEM-10B were adjusted: J_2, J_3 and two pairs of resonant coefficients at orders 16, 17, 33, 49, 82, 164

- Comparison of the final nominal orbit to S8703

	SAT #1		SAT #2	
Direction	RMS (m)	Max Error (m)	RMS (m)	Max Error (m)
Radial	18	64	18	64
Along-track	61	206	61	209
Cross-track	17	69	17	72

TIME OF FLIGHT VS. TIME FOR
THE RECEPTION OF SATELLITE TWO



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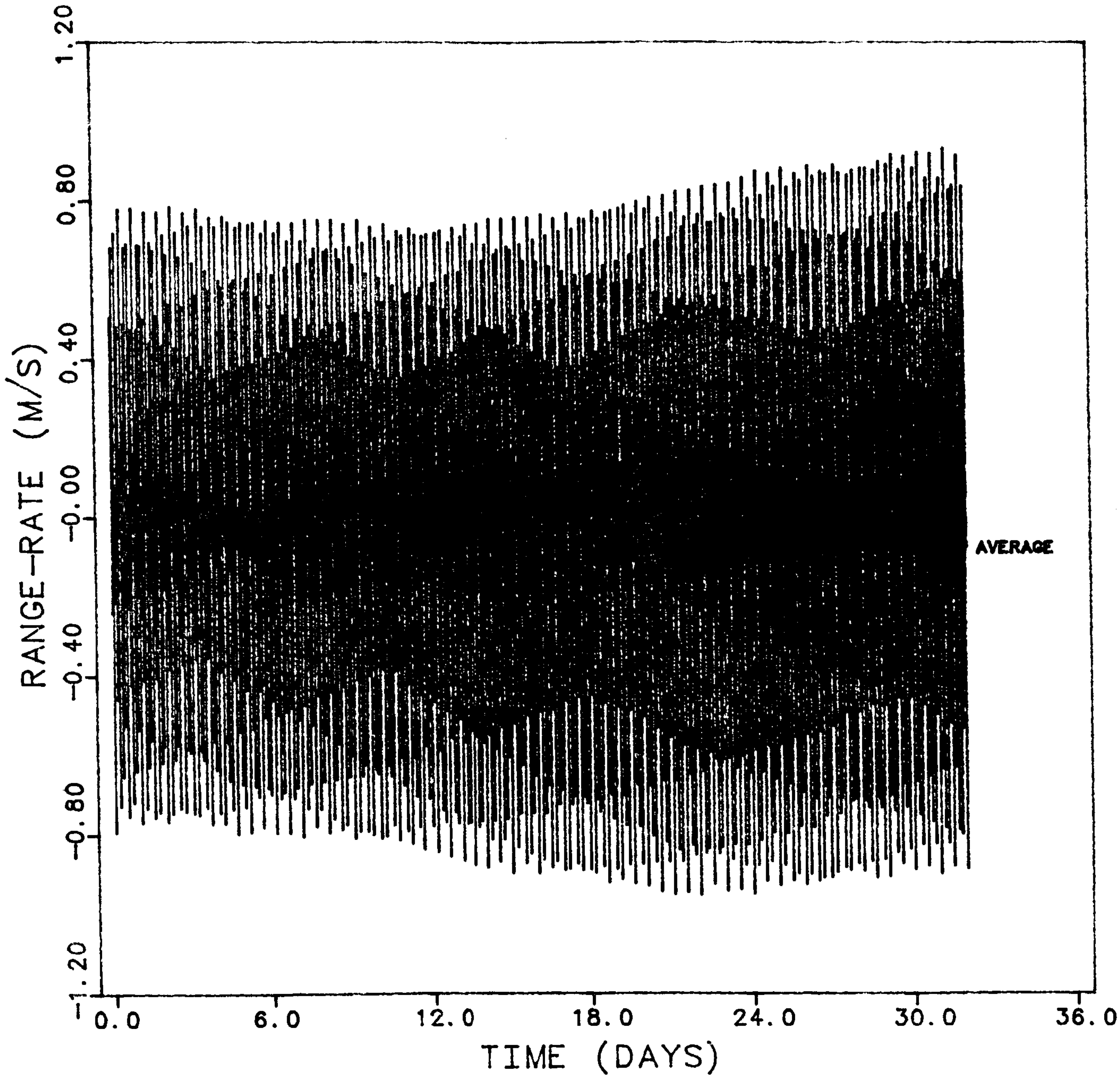
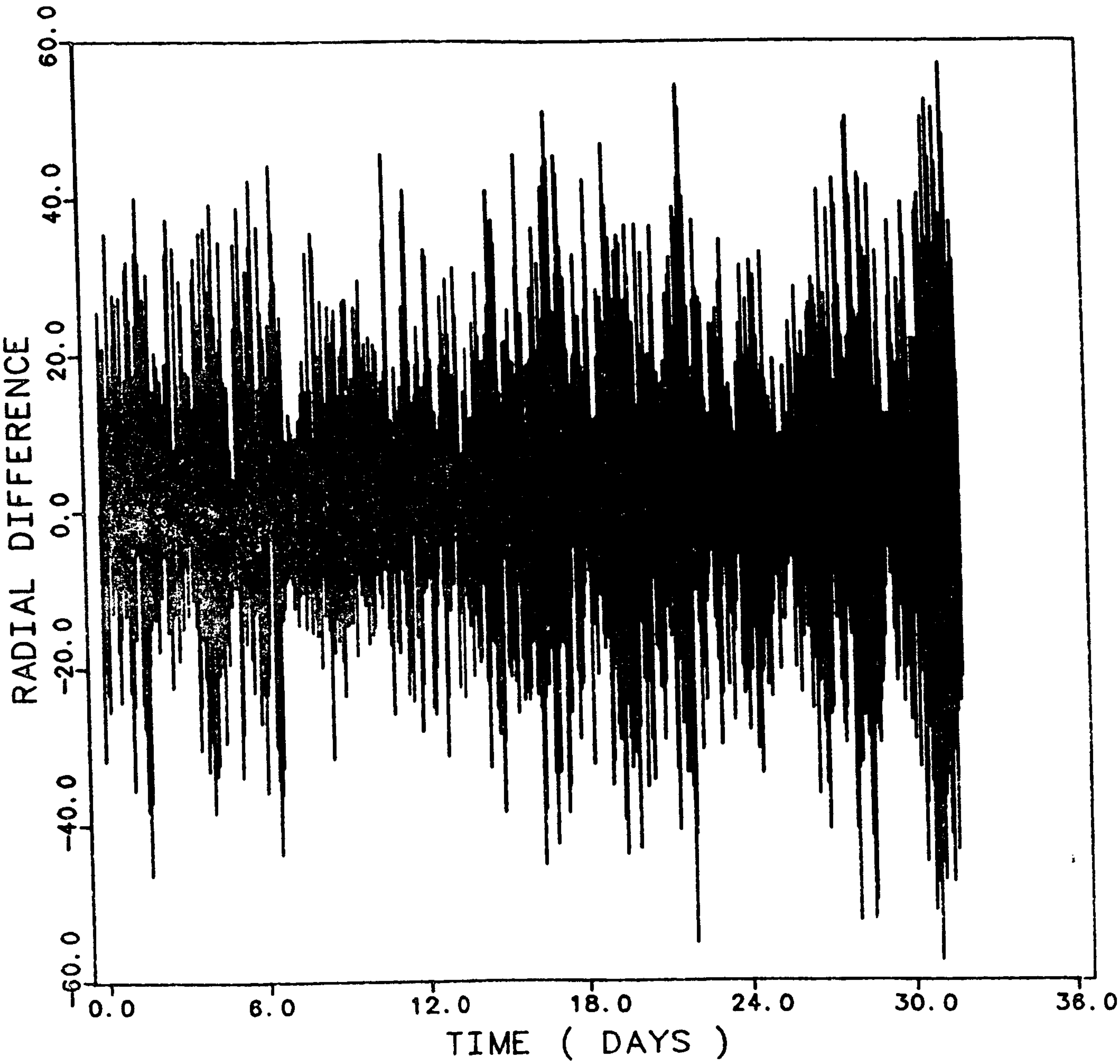
THE AVERAGE RANGE-RATE OF THE TWO DOPPLER MEASUREMENTS VS. TIME



RESIDUALS BETWEEN FULL FIELD AND
GM10B 36X36 PLUS SELECTED HARMONICS FOR SAT 1



RESIDUALS BETWEEN FULL FIELD AND
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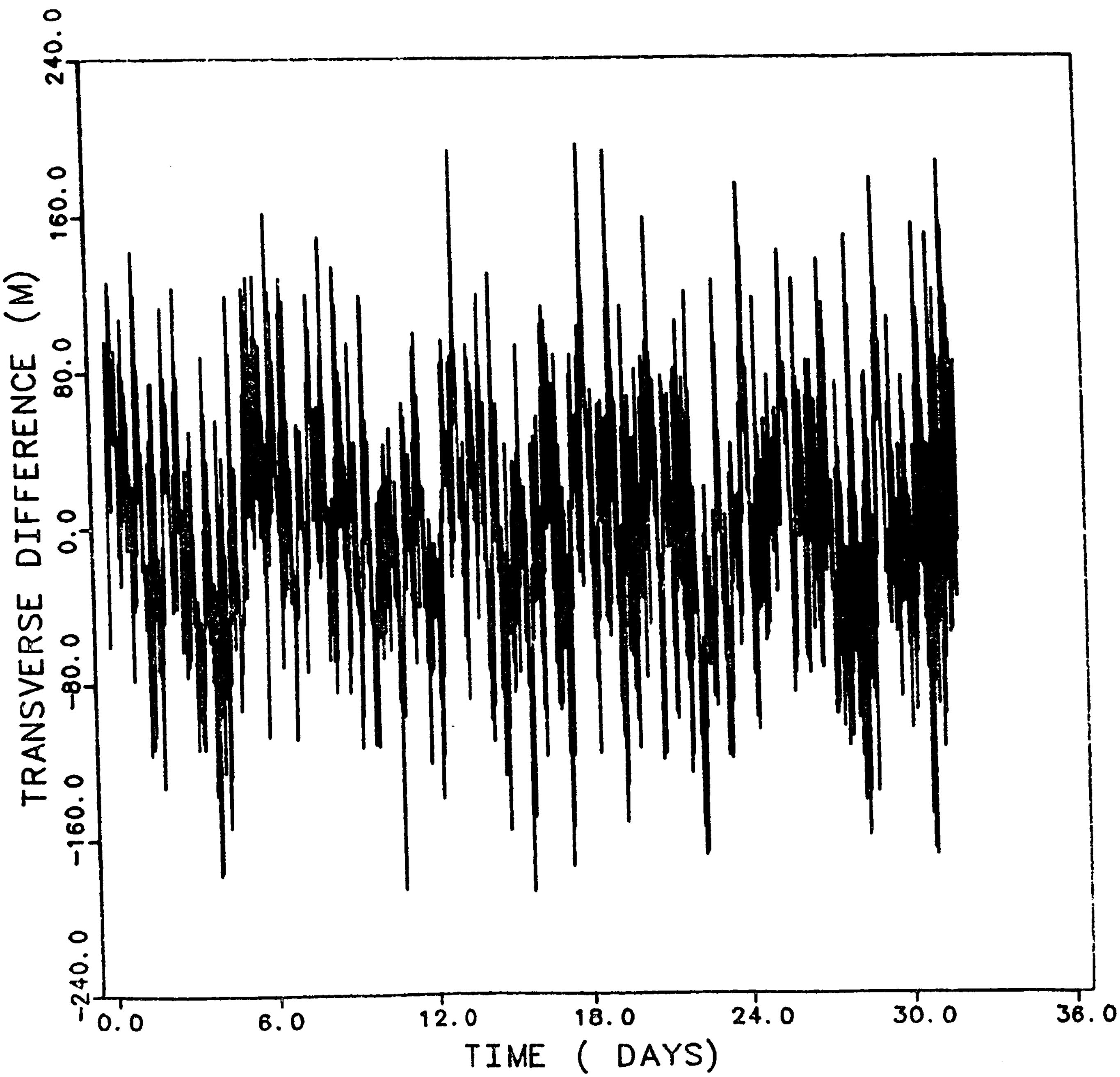

RESIDUALS BETWEEN FULL FIELD AND
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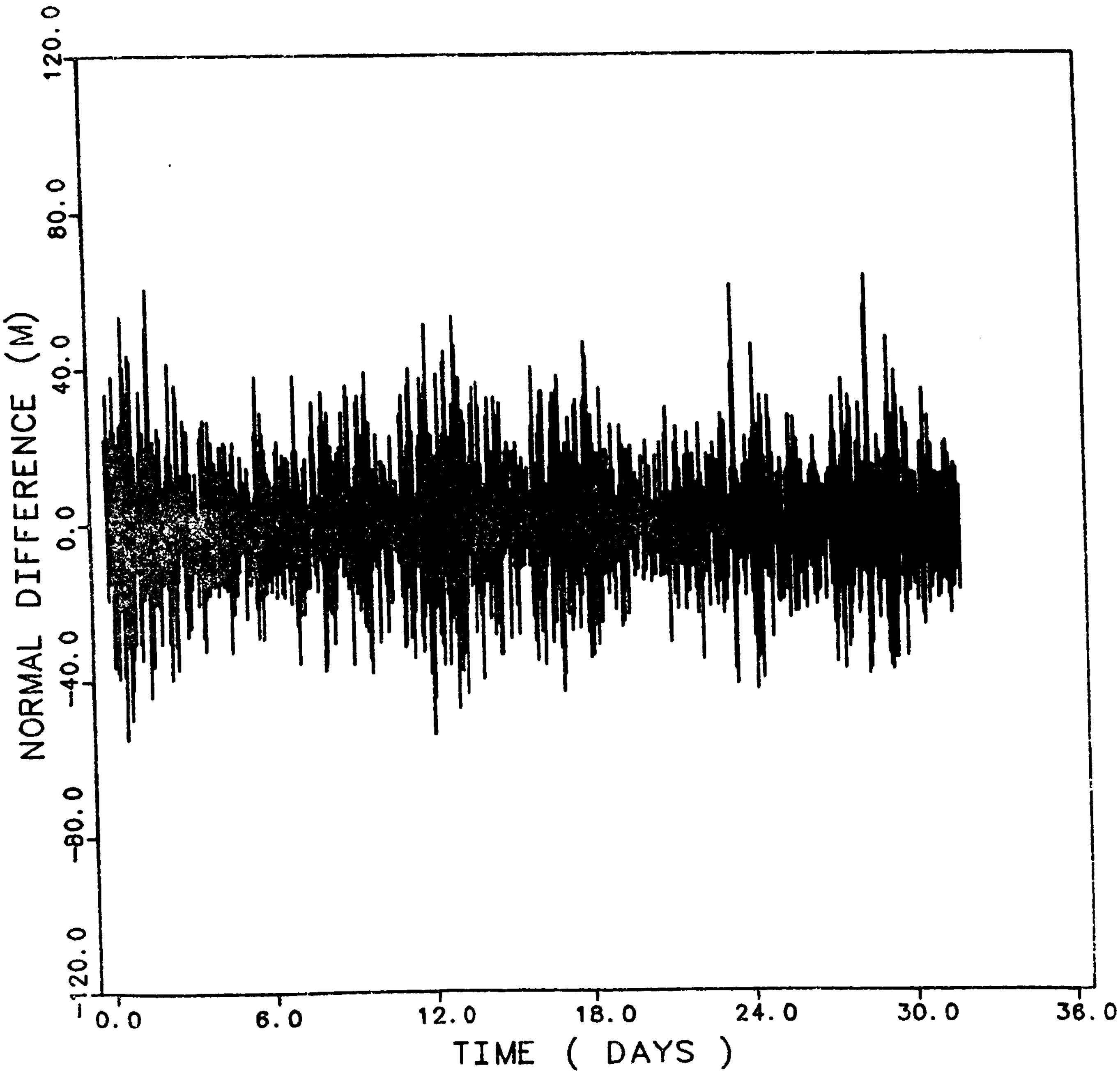
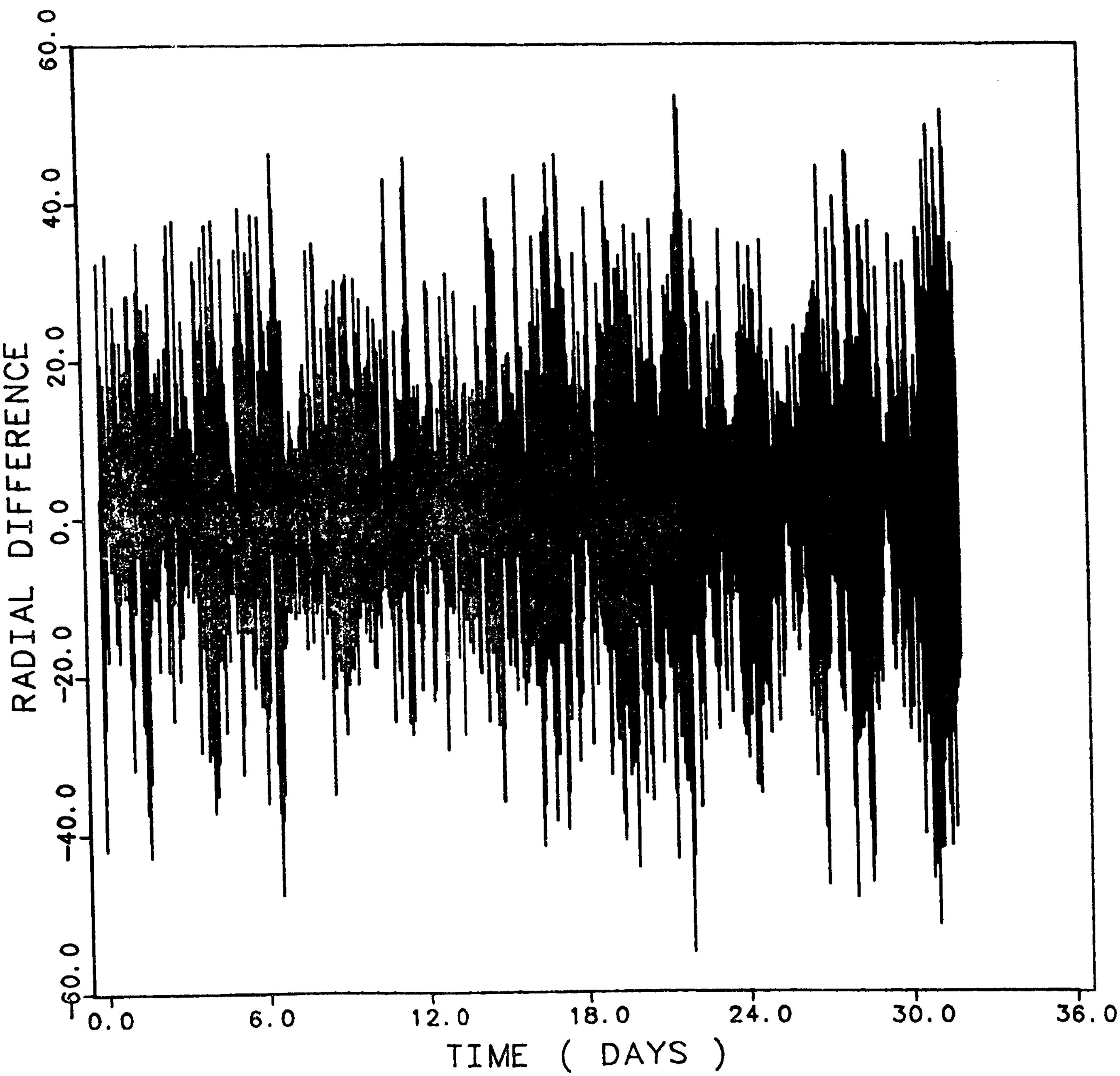
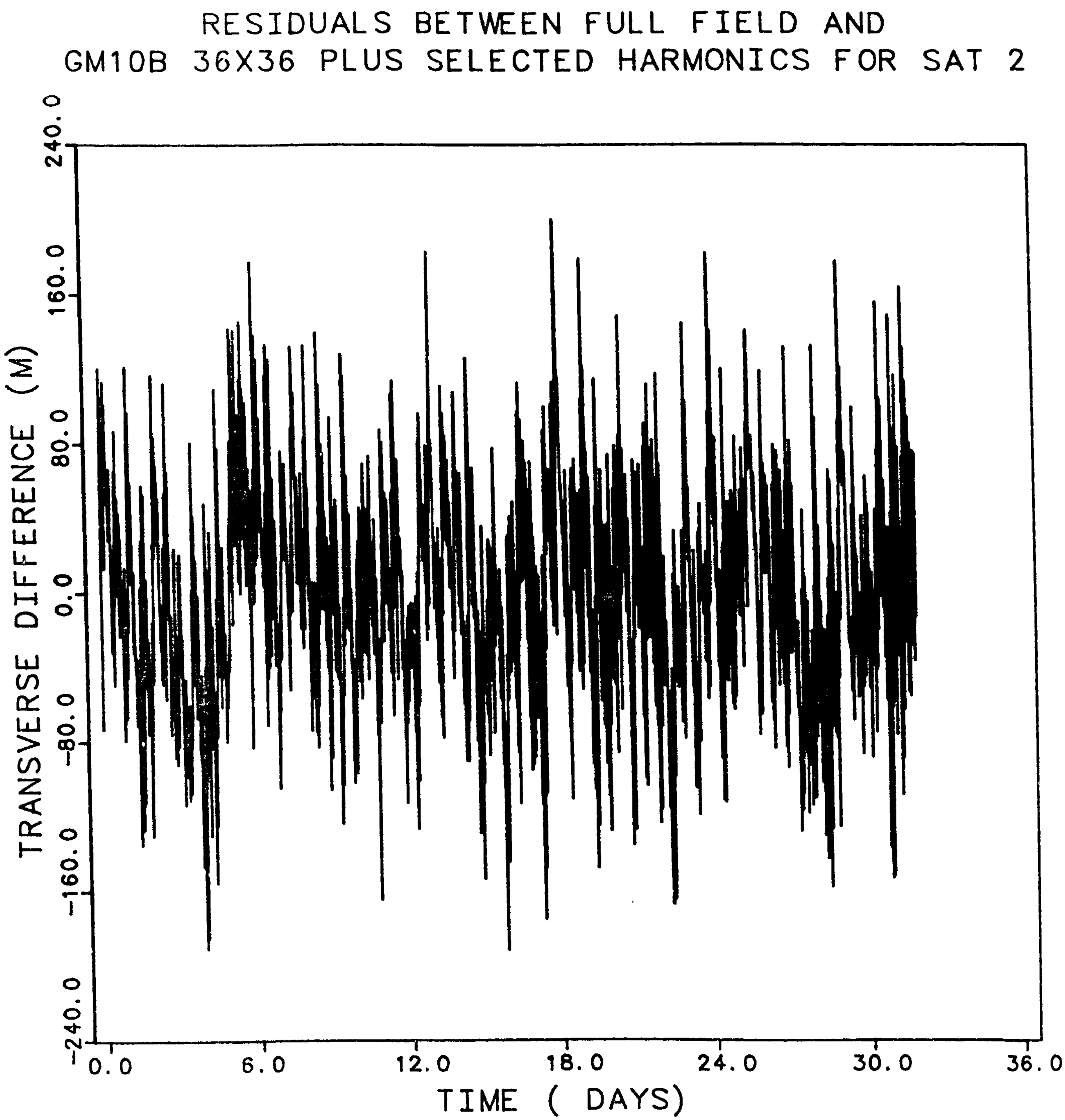


RESIDUALS BETWEEN FULL FIELD AND
GM10B 36X36 PLUS SELECTED HARMONICS FOR SAT 2





RESIDUALS BETWEEN FULL FIELD AND
GM10B 36X36 PLUS SELECTED HARMONICS FOR SAT 2
TRANSVERSE DIFFERENCE (M)
240.0
160.0
80.0
0.0
-80.0
-160.0
-240.0
0.0
6.0
12.0
18.0
24.0
30.0
36.0
TIME (DAYS)

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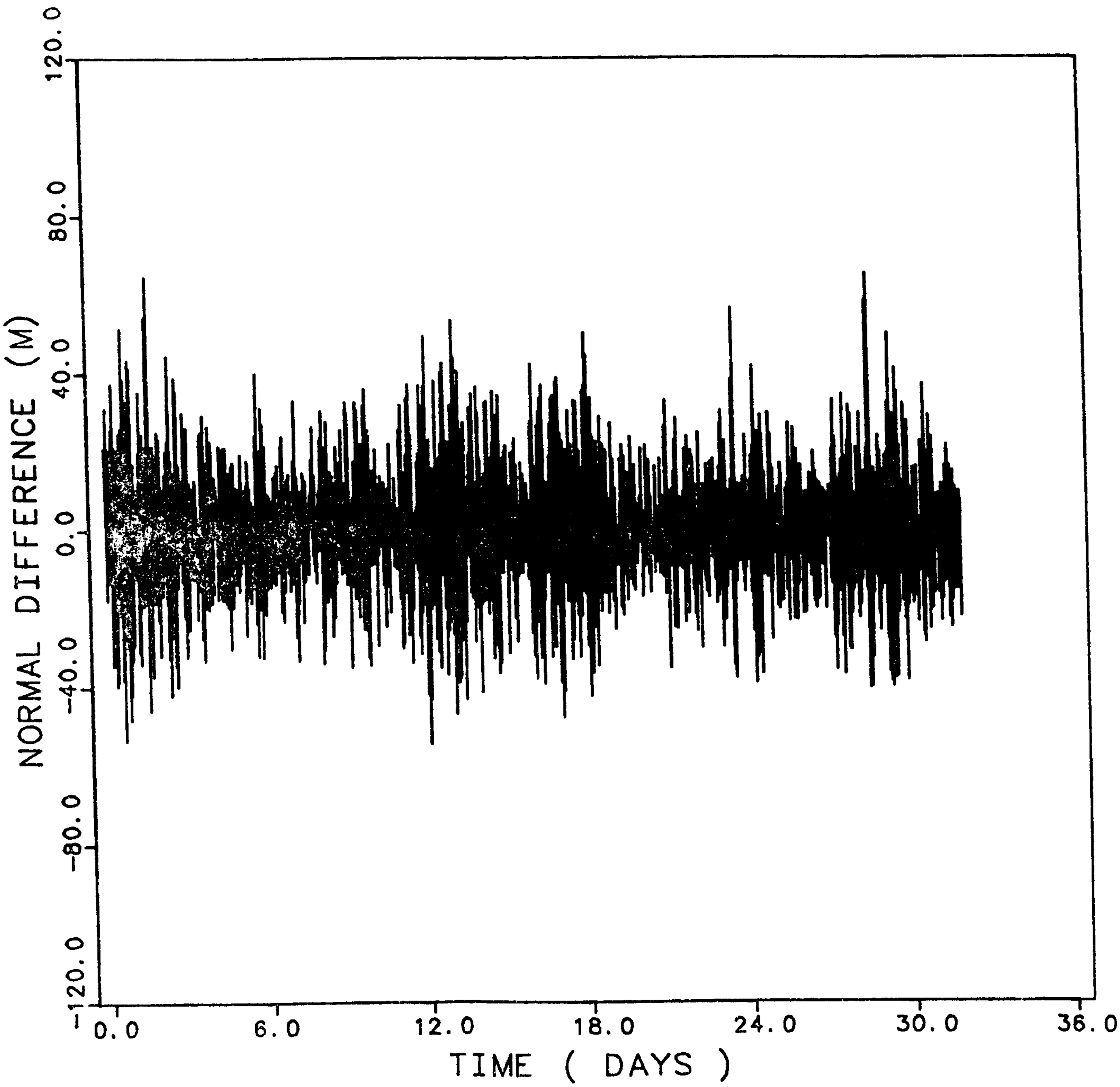
RESIDUALS BETWEEN FULL FIELD AND
GM10B 36X36 PLUS SELECTED HARMONICS FOR SAT 2



DATA SET TO BE DISTRIBUTED

At four-second intervals:

t	time tag
$\Delta\dot{\rho}_{n,i}$	integrated one-way doppler measurements along the nominal orbit received at satellite i
$\Delta\dot{\rho}_{s,i}$	integrated one-way doppler measurements along the simulated orbit received at satellite i
ε_i	pseudo-noise parameter
$(\bar{r}_n,\dot{\bar{r}}_n)_i$	position and velocity vectors of the nominal orbit for satellite i

Nominal gravity field

True gravity field